LEHIGH AIR-ENTRAINING CEMENT

What it is · What it does · How it should be used

The picture on the cover is a general view of the concrete runway at Syracuse Air Base, Syracuse, New York, for the United States Engineers. Grading and Excavation by D. W. Winkleman. Paving by Warren Bros. Roads Co. General Contractors.

LEHIGH *Air-Entraining* CEMENT

What It Is • What It Does How It Should Be Used

One of the outstanding accomplishments of recent years in the field of concrete is the development of what has come to be called Air-Entraining Cement. The Research Laboratory of the Lehigh Company has played an important part in the development and improvement of this new product and will continue to work for its further improvement.

All concrete contains a certain amount of entrained air but exhaustive research has shown that if concrete is so made as to incorporate a certain amount of air in the form of very fine bubbles, it will be more plastic and cohesive and, under certain circumstances, will be more durable.

On the other hand, if the amount of entrained air is too great it will cause a considerable reduction in the weight and strength of the concrete. Hence, it is important that the air content be carefully controlled.

There are a number of resinous and fatty materials which, added to portland cement, serve as air-entraining agents. Beef tallow, fish oil stearate and commercial materials called "Vinsol Resin" and "Darex" all give good results. The latter two are approved by the American Society for Testing Mate-

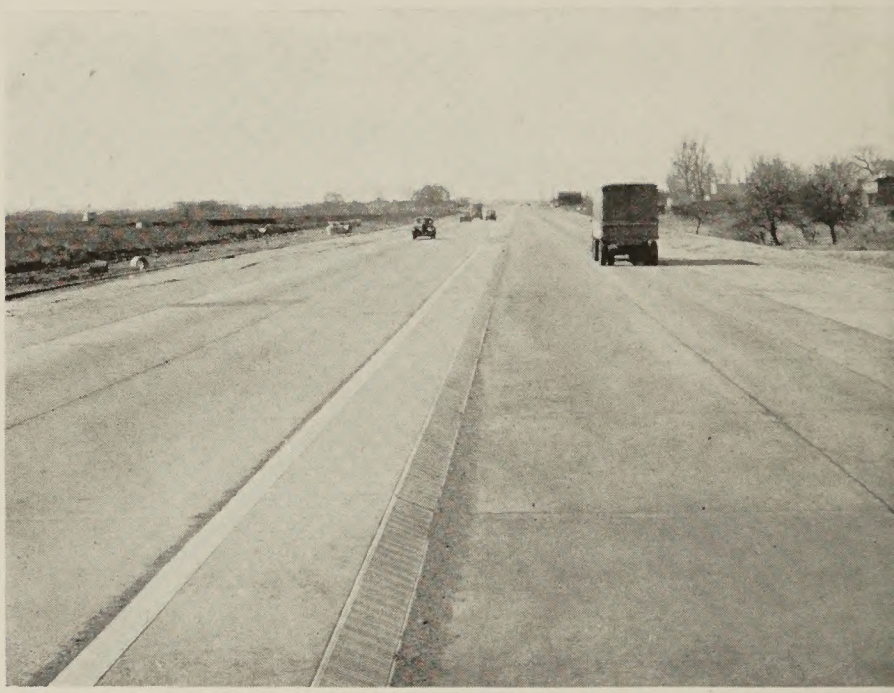
rials in its specifications for Air-Entraining cement, and one or the other is now used by all producers complying with this specification.

What are the Problems AIR-ENTRAINING CEMENT *Helps to Solve?*

It should be made clear that concrete made with normal portland cement, properly designed, mixed and cured will be perfectly sound and durable. Thousands of concrete jobs in every field of use make this fact self-evident.

Frequently, however, the conditions under which concrete is made and placed are not ideal and the durability of the work may be affected. The most common of these conditions is known as "bleeding" or "water rise." This means simply that sometimes as concrete is placed the heavier material settles and displaces water, which is forced to the surface of the concrete. Wherever such water appears it means that channels have been opened in the concrete, which remain open after hardening.

Through these channels outside water can gain entrance to the concrete, causing danger of damage from freezing and

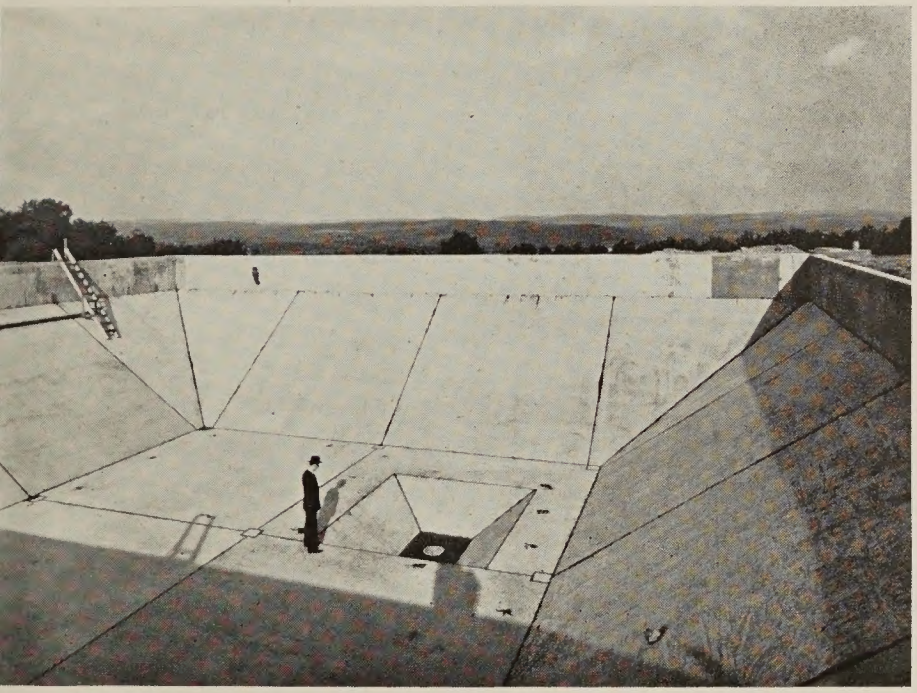


Paving on Route 762 near Philadelphia for the Commonwealth of Pennsylvania. Contractors: F. A. Canuso & Son.

thawing. On concrete highways in northern climates where salt or calcium chloride are often used to remove ice, there is an added danger. These salts, in solution, may enter the concrete, form crystals as water evaporates, and so exert expansive force great enough to cause surface scaling and eventual disintegration.

These, stated simply, are some of the problems which air-entrained concrete helps to solve.

Concrete Reservoir for the United States Engineers.
General Contractors: John W. Ryan Construction Co.



What does AIR-ENTRAINING CEMENT *do?*

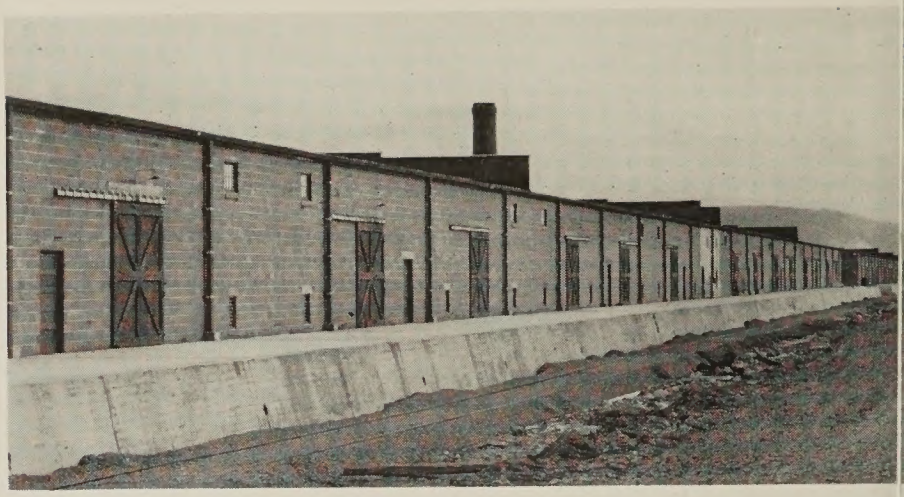
When water is added to a batch of concrete materials, including an air-entraining agent, air is entrained into the concrete in the form of minute bubbles evenly distributed through the mass. This entrained air does several important things—

(1) It serves as a lubricant, so it is possible to reduce the amount of water per bag of cement and yet improve the plasticity of the mix. Such concrete is more plastic and cohesive, without any apparent excess water, and is readily placed and quickly consolidated.

(2) Any tendency toward bleeding is greatly reduced because the minute bubbles of air surround the particles of heavier materials, preventing them from settling and forcing water to the surface. Bleeding channels which would give outside water entrance to the concrete are reduced to a minimum.

(3) Small pores (far smaller than bleeding channels) exist in all concrete and permit some water to enter. The tiny bubbles of entrained air furnish protection against freezing and thawing by providing room for expansion within the concrete. While this is important in any concrete, it is doubly so on pavements where salts are used, and crystal pressure adds to the expansive force created by freezing.

(4) Because less water rises to the surface of the concrete, finishing operations are speeded up.



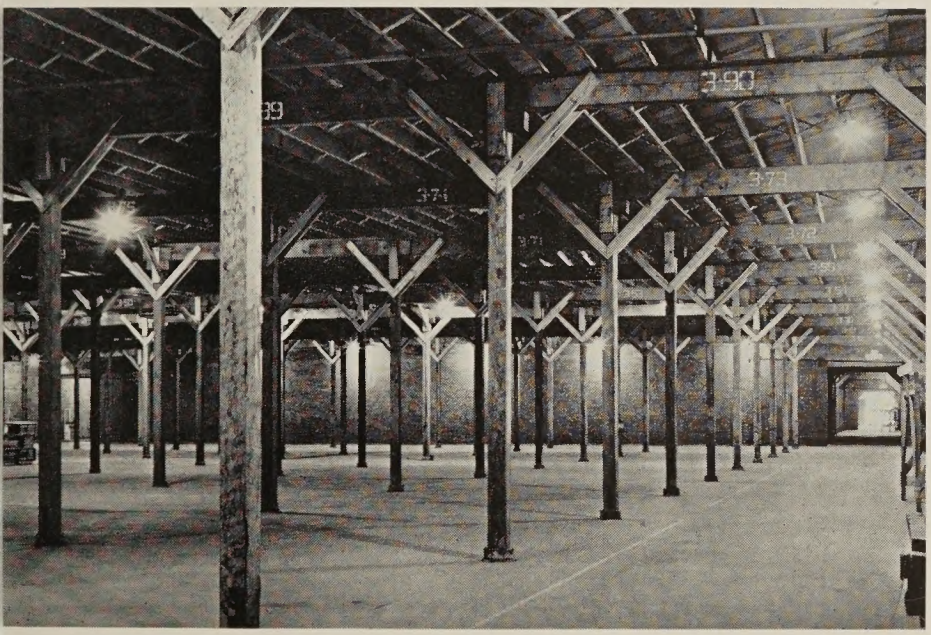
Warehouse platform at a Holding and Reconsignment Point for the United States Engineers.

For what Work can AIR-ENTRAINING CEMENT *be Used?*

Concrete Highways, Sidewalks, Curbs and Gutters

Air-Entraining cement was developed primarily for use in this field. We recommend its use on all such work. Modern traffic demands that highways and streets be kept

View of interior floor of a Medical Depot for the United States Engineers. General Contractors: Westover-Wolf, Inc. Sub-Contractor for Masonry and Concrete: Folino & Twisdale.



open in all weather. In northern climates ice removal requires frequent use of salt or calcium chloride. This fact, combined with frequent cycles of freezing and thawing, puts concrete to its severest test. During the past five years we have supplied hundreds of thousands of barrels of Lehigh Air-Entraining cement for highway projects with uniformly good results. These roads are standing up extraordinarily well and show little or no surface scaling after several years of service. Many of them have had severe use under heavy war traffic, although salts have been used regularly for ice removal.

For sidewalks, curbs and gutters, on which leaner mixes are used than for heavy duty pavements, Air-Entraining cement is especially desirable. The added protection from surface scaling gives added durability for all such work.

Foundations, Walls and Floors

On such work, Air-Entraining cement permits a reduction in mixing water, thus reducing bleeding, yet gives added plasticity to permit the concrete to be readily placed, quickly consolidated and promptly finished. In structural concrete bleeding has always been a particularly troublesome problem. Small sections and intricate reinforcement require reasonably fluid concrete for proper placing. Fre-

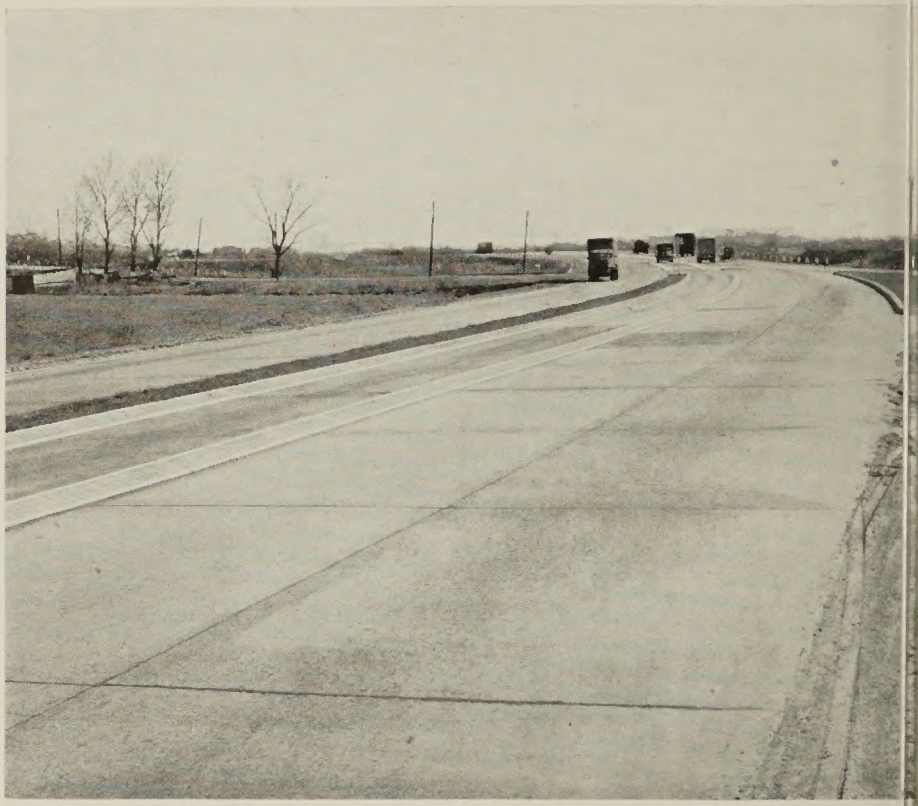
quently this has led to the use of excess water. The smaller amount of water required for air entrained concrete helps to correct much of this difficulty.

There is still some question as to whether air entrained concrete suffers by reduction in the strength of the bond between the concrete and the steel reinforcement. Considerable research is still in progress on this point. The consensus of opinion at this time is that the reduction in bond strength, if any, is very slight and not sufficient to cause any concern.

Concrete Masonry Units

In this field the advantages of Air-Entraining cement are in the greater plasticity and cohesiveness that it gives to the concrete mix. Many products manufacturers are using Air-Entraining cement entirely and report that they are producing units of improved appearance, lower absorption and without loss of weight and with equal or greater strengths, together with considerable reduction in the number of imperfect units or culls.

We believe that every manufacturer of concrete masonry units would do well to make comparative tests of normal and Air-Entraining cements with his own materials to determine which offers him the greater advantage in improved units.



Another view of the highway development along Route 762.

Concrete Pipe

Manufacturers of machine made pipe will also find it worth while to test the use of Air-Entraining cement. Many of our customers in this field report that its use gives pipe of better appearance and somewhat lower absorption, with no reduction in strength and with considerably less breakage.

View of warehouse for the United States Engineers.

Some Things to Remember about AIR-ENTRAINING CEMENT

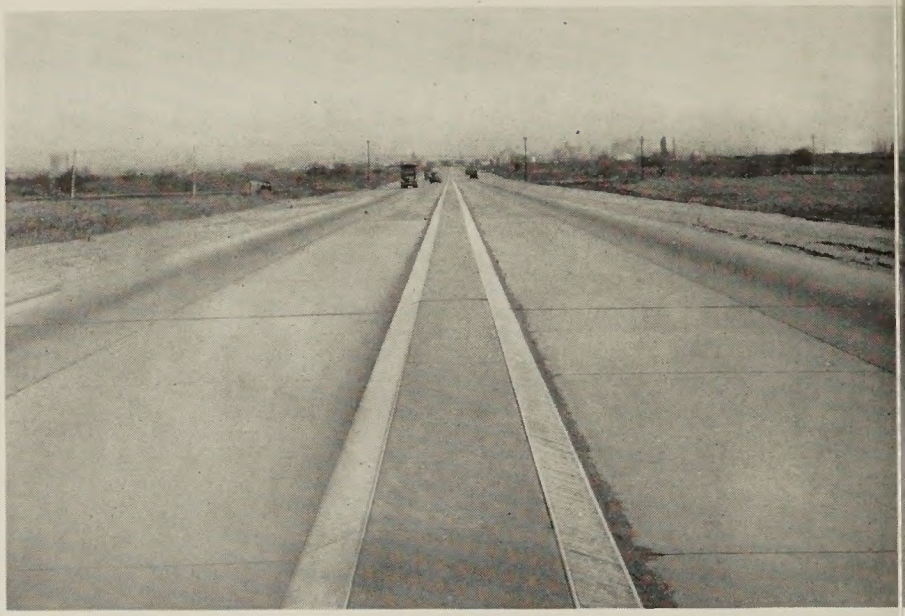
It is not a cure for all concrete problems. It is a cement that has been going through various steps of development and improvement and which will find a growing field of usefulness.

The original method of adding the air-entraining agent in cement manufacture frequently led to unpredictable results in the amount of air entrained in the concrete, and to fluctuating concrete weights and strengths. During the past year a new method of adding the air-entraining agent has been developed and incorporated in the specifications, which gives greatly improved results.

To get the full benefit of Air-Entraining cement, with a minimum reduction in strength, the water and sand content of the concrete batch needs to be reduced. The final section of this booklet describes a simple outline of the methods that will give the best results.

A given Air-Entraining Cement will sometimes work differently with different aggregates. It is always desirable, therefore, before starting a concrete job, to make trial batches with the material to be used, to determine from the weight of the concrete that the air content is controlled as desired. It is also a wise precaution to test for unit weight regularly during the progress of the work, to make certain that the air content is kept under control.

Some authorities believe that better results are gained by adding the air-entraining agent at the mixer, rather than to incorporate it in the cement. A number of ready-mix concrete producers follow this method. The procedure is entirely sound. Where the operation is under careful supervision it affords opportunity to correct any variations in air content by simply varying the amount of air-entraining agent. The disadvantage is that it becomes necessary to make sure that one more material is correctly added to each batch.



Highway for the Commonwealth of Pennsylvania.

Construction of concrete roadway at an Air Base for the United States Engineers.

How to Use
AIR-ENTRAINING CEMENT

The new A.S.T.M. specification, C 175-44-T, controls the manufacture of air-entraining cement, but the type of aggregate, the character of the mix and the water content also have an effect on the amount of air entrained. For this reason trial mixes are required so that the mix quantities may be adjusted to secure the desired properties. As the job progresses, occasional tests for unit weight should be made to insure the maintenance of these qualities.

The first step is to make a sample batch, using normal cement of the proportions and consistency necessary to give concrete of the required workability and strength. The weight per cubic foot of this concrete and the quantities of material used for it become the basis for calculating the air-entraining mix.

Air entrainment will reduce the unit weight of the concrete by the amount of the materials and water displaced by the added air. Experience thus far indicates that the best results are obtained by an air entrainment of about 3%.

The air entrainment also causes a loss of strength. Much of the loss, however, can be made up by reducing the sand

content by an amount proportional to the volume of entrained air. This reduction in the sand will permit the use of less water per sack of cement and the resulting lower water-cement ratio will raise the strength.

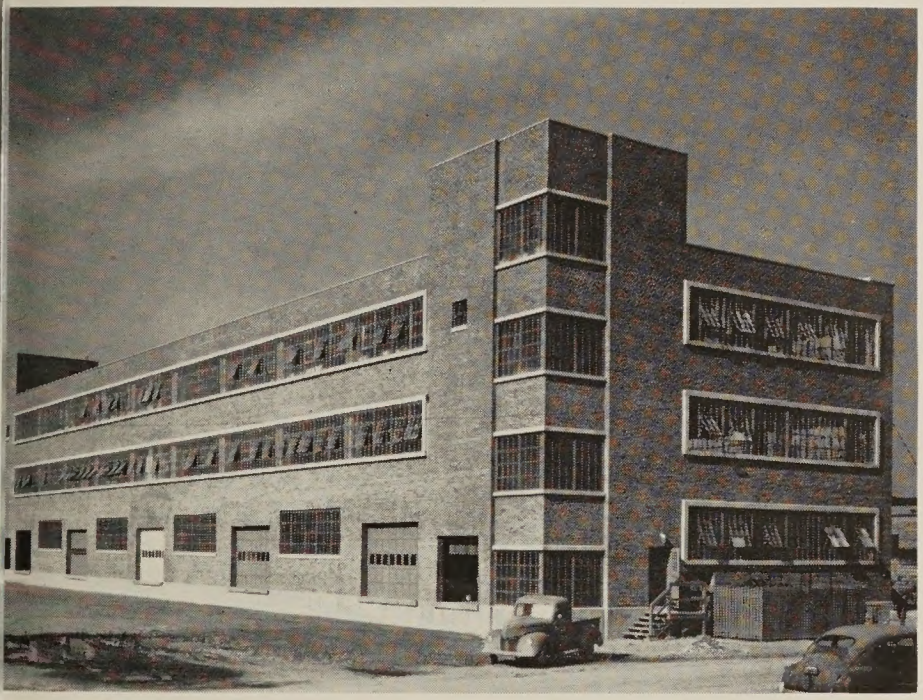
For the trial mix with Air-Entraining cement, reduce the quantity of sand by 3% of the total weight of both the fine and coarse aggregates used in the normal mix, and use only enough water to provide equal workability. This will usually permit a reduction per sack of one quarter to three quarters of a gallon or more.

The unit weight of the trial mix should then be determined. If the loss as compared to the normal mix is more than desired, another trial mix may be made with a further reduction in sand and water.

In the foregoing trial mix with Air-Entraining cement it may be assumed that the per cent of entrained air is the same as the drop in weight per cubic foot in pounds. This is not exactly true but it will serve as a guide for the further adjustment of the air-entrained mix if the first trial batch shows a drop in weight greater than 3 pounds per cubic foot. For instance, if the weight loss is found to be 5 pounds per cubic foot, then for the second trial mix reduce the quantity of sand by 5% of the total weight of both the fine and coarse

A view of interior of an Air Base warehouse for the United States Engineers. General Contractors: John W. Ryan Construction Co.

Outside view of Air Base warehouse for the United States Engineers.



aggregates used in the normal mix. This proeedure will very nearly compensate for the volume increase eaused by the entrained air. It will also result in strength recovery, for the greater reduction in sand will further reduce the quantity of water required to maintain workability. Since the strength recovery depends on this reduction in water, it is highly important that the original slump of the normal mix be not exceeded.

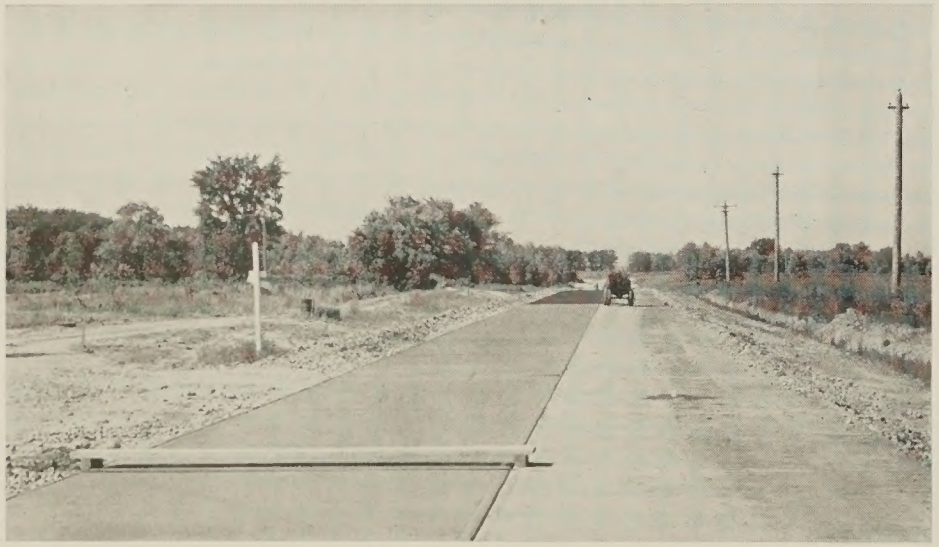
To those who are familiar with determining conerete quantities, it will be apparent that if the first trial mix shows only the desired weight loss, the yield will be approximately equal to that of the normal mix. If the weight loss is greater than that desired and if the further adjustment deseribed in the preceding paragraph has been made, the yield will be slightly less than that of the normal mix. In any case, the normal yield ean be restored by a small addition of eoarse aggregate.*

Somewhat more loss in strength can be expeeted in the rieh mixes for they normally require less water per saek of cement than the lean and the extent of the reduetion ean not be as great. With elose eontrol, however, they will provide a safe margin over design requirements and the added durability will more than compensate for the slight losses.

* A standard method of test for Weight per Cubic Foot, Yield and Air Content is prescribed in A.S.T.M. specification C 138–44 and copies are available for your use.

Variations in the aggregates and the quantity of water during the progress of the job may affect the amount of air and the weight and strength of the conerete. Frequent weight tests will detect these ehanges and permit sueh adjustments as may be neeessary to hold the strength at the level originally determined.

Always remember that it is important to take full advantage of the increased plasticity of the air-entrained eonerete and use only the amount of water neeessary for satisfactory plaeing eonsistency.



Roadway construction at an Ordnance Depot for the United States Engineers. General Contractors: Potter-DeWitt Corp.

In Air-Entraining Cement, the construction industry has at its command a modern product, of great possibilities. The Lehigh Service Department will be glad to work with you in applying its possibilities to your work. Lehigh Air-Entraining Cement is manufactured at all Lehigh mills. It is shipped in bulk, and in paper or cloth bags. It may be shipped in carload lots, or in mixed carloads with other Lehigh Cements.

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